

1     **TITLE: Welded Hip Prosthesis**

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4             This application is related to an application entitled,  
5     Split Sleeve Modular Joint, S. N. 09/982,448, by the same  
6     inventors.

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8     **FIELD OF THE INVENTION**

9             This invention relates to the medical field of orthopaedics  
10     and joint replacement, in particular. Modular artificial joints  
11     have several components that must be assembled and placed in the  
12     patient to reconstruct a joint. While modular joints provide the  
13     ability to custom fit an artificial joint to a patient's anatomy,  
14     the connection between the components must be without relative  
15     movement after implantation. This invention is directed to a  
16     modular artificial joint construction which provides a locking  
17     mechanism to secure the components immovably together.

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19     **BACKGROUND OF THE INVENTION**

20             Artificial joints or prosthesis have now been constructed  
21     for almost every natural joint in the living body. As the  
22     medical field gains more understanding of the problems involved  
23     in mating inanimate constructions with animate tissue and  
24     designing mechanical devices that can duplicate natural movement,

1 the number of implantations will continue to increase. In  
2 addition to the major joints, such as the hip, knee, shoulder,  
3 elbow, wrist and ankle, better engineering of the prosthesis,  
4 accompanied with miniaturization, will permit smaller and smaller  
5 natural joints, eg. vertebrae, phalanges, tarsals and  
6 metatarsals, to be reconstructed. Until now, the larger joints  
7 have received the most attention mainly because of the larger  
8 size of the bones. The prosthesis of this invention may be  
9 utilized in all joints.

10 In replacing a hip joint, the head of the femur is removed  
11 along with the ball. The trochanter portion of the femur is  
12 shaped and prepared for receiving the prosthesis so that the  
13 artificial joint will closely approximate the natural hip.

14 Earlier artificial hip joints were made of one-piece  
15 construction requiring a large inventory of prosthesis to  
16 accommodate the various sized patients. The modular artificial  
17 joint has two or three or more elements which replace the natural  
18 hip. By manufacturing these components with interchangeable  
19 connections but different external sizes, inventories may be  
20 smaller because of the ability to mix and match components.  
21 Also, the modular prosthesis provides more flexibility in  
22 customizing the various components of a joint to the various  
23 parts of a patient's natural joint.

24 In a three piece artificial hip joint, the various sized

1 components of the joint that may be selected are the  
2 intramedullary rod, the trochanter and the neck. The  
3 intramedullary rod is inserted into the end of the femur. The  
4 rod acts as a stabilizer in maintaining the artificial joint in  
5 the axis of the femur. The upper portion of the rod which  
6 extends out of the femur is fitted into a trochanter element  
7 which is shaped like the removed broad head of the femur which it  
8 replaces. This element, along with the rod, is used to adjust  
9 the length of the prosthesis to approximate the natural length of  
10 the femur.

11       The natural trochanter is the broadened area offset from the  
12 end of the femur. The natural trochanter may be at any radial  
13 angle about the axis of the femur. This natural angular  
14 relationship must be reproduced by the intramedullary rod and the  
15 artificial trochanter. The artificial trochanter is seated on  
16 the end of the patient's femur and is the main load bearing  
17 element of the prosthesis. It is important that this load, which  
18 is mostly compression, is transmitted along the axis of the  
19 femur.

20       A neck element is inserted into the trochanter element and  
21 carries an extension onto which the ball joint will be fixed.  
22 The horizontal angle between the trochanter and the neck  
23 extension is variable to reproduce the anteversion angle of the  
24 patient's natural joint. The neck carries cantilevered forces in

1 torque and compression between the acetabulum and the trochanter.  
2 It is also important that these forces do not result in relative  
3 movement between the trochanter and the neck.

4 All these elements have a central bore and are permanently  
5 secured together by a bolt which is inserted into the neck  
6 element, extends through the trochanter element, and is threaded  
7 into the upper end of the rod. In some cases, the  
8 intramedullary rod may be attached to the bone with bone cement  
9 while, in other cases the cement is omitted.

10 When the cement is omitted, the placement and fixation of  
11 the intramedullary rod becomes more critical to pain free usage  
12 of the prosthesis. Further, it is most important that the  
13 intramedullary rod not be disturbed after insertion since this  
14 would corrupt the union between the rod and the interior of the  
15 femur.

16 In order to maintain the original union between the femur  
17 and the intramedullary rod, modular prosthesis have been  
18 developed to allow rotational adjustment of the several parts or  
19 elements about the emplaced rod during the placement of the  
20 prosthesis to more closely reproduce the natural structure of the  
21 hip. It has been found that, in some cases, as the  
22 intramedullary rod has been inserted into the bone canal, there  
23 is rotational movement of the rod. In order to preserve the  
24 union between the rod and the bone, there must be a mechanism to

1 accommodate the changed angular orientation of the proximal end  
2 of the intramedullary rod so that the prosthesis closely  
3 approximates the natural trochanter and ball.

4         While the above description refers to a modular hip  
5 prosthesis, substantially the same considerations must be given  
6 to other modular prosthesis, such as a knee prosthesis in which  
7 an intramedullary rod is placed in the lower end of the femur and  
8 in the upper end of the tibia or the elbow in which an  
9 intramedullary rod is placed in the lower end of the humerus and  
10 the upper end of the radius or ulna. Because of individual  
11 physical anomalies, the functional prosthesis must be capable of  
12 angular adjustment to conform to the natural physique.

13         With the advantage of flexibility gained by modular  
14 prosthesis, there comes the requirement that there be no movement  
15 between the several parts or elements after implantation. These  
16 movements may cause misalignment of the joint resulting in  
17 increased pain, trauma to the joint and, even, dislocation of the  
18 joint.

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#### 20 DESCRIPTION OF THE PRIOR ART

21         The prior art is replete with artificial prosthesis and hip  
22 joints, in particular.

23         Illustrative of the state of the art is U. S. Patent No.  
24 5,876,459 to Powell which discloses a modular hip joint having a

1 stem, one end of which is inserted in the intramedullary canal.  
2 The other end of the stem is tapered to fit within a second,  
3 neck, element. The neck ultimately supports the ball joint. A  
4 sleeve element is placed over the junction of the first two  
5 elements. All three elements are rotationally movable relative  
6 to each other. A bolt is driven through the bore of the neck  
7 and stem deforming a portion of the interconnected elements for a  
8 friction fit between the neck and the stem. These prior art  
9 patents disclose that the sleeve may have a polygonal shaped bore  
10 with the articulating elements having corresponding shaped  
11 portions. The interconnected elements of these hip joints do not  
12 form a static lock between each other but require a deformation  
13 of one or more elements before a friction fit is established.  
14 The deformation and friction fit is between the stem and the neck  
15 rather than the sleeve and the stem.

16 U. S. Patent No. 5,653,765, to McTighe et al discloses a  
17 modular hip joint with a stem, an intermediate shoulder portion,  
18 and a proximal shoulder piece which attaches to the ball. The  
19 stem and the intermediate shoulder portion have interengaging  
20 teeth on the corresponding ends of each by which they are  
21 connected. This end-to-end connection allows for rotational  
22 movement of the elements relative to each other. The proximal  
23 shoulder piece and the intermediate shoulder piece also have an  
24 end-to-end toothed connection for rotational adjustment. This

1 construction has two movable end-to-end connections which provide  
2 good flexibility for rotation of the elements but have small  
3 surface areas of fixation to each other limited to the surfaces  
4 of the interengaged teeth.

5 The Leto patent, U. S. Patent No. 4,419,026 issued Dec.  
6 6, 1983, discloses a resilient split sleeve camming lock for use  
7 with telescoping tubular elements. The system relies on the  
8 resilience of the split ring and does not require a permanent  
9 deformation of the split sleeve by longitudinal displacement.

10 White et al, U. S. Patent No. 5,725,592, disclose a three  
11 piece hip prosthesis with an artificial trochanter,  
12 intramedullary rod, and a neck for supporting the ball. The  
13 components are connected by complementary tapers.

14 U. S. Patent No. 5,702,480, of Kropf et al, also have  
15 similar components.  
16

#### 17 SUMMARY OF THE INVENTION

18 In the instant invention a modular prosthesis is taught  
19 which has an intramedullary rod element which is to be inserted  
20 in a bone. The rod is a sub-assembly which includes a tapered  
21 extension allowing a movable connection between the proximal end  
22 of the rod and an elongated link. The proximal end of the  
23 intramedullary rod is permanently connected to the tapered  
24 tubular extension. The tapered extension is telescoped into one

1 end of a bore in the artificial trochanter of the hip prosthesis.  
2 The mating surfaces of the extension and the weight-bearing  
3 trochanter bore are shaped to permit 360° rotation of the  
4 extension within the bore. The tapered wall shapes of the  
5 extension on the rod and the bore are complementary. This  
6 mechanism allows the trochanter to be rotated on the tapered  
7 tubular extension of the intramedullary rod without disturbing  
8 the placement of the rod in the intramedullary canal.

9 The internal wall of the tapered tubular extension is also  
10 tapered as is the external wall of the link. The proximal end of  
11 the link has an internally threaded bore for accepting a bolt.

12 Upon relative longitudinal movement between the trochanter  
13 bore and the tapered tubular extension a rotationally immovable  
14 connection is formed between the intramedullary rod and the  
15 weight-bearing element.

16 The artificial ball element is telescoped into the other end  
17 of the trochanter bore permitting additional rotational  
18 adjustment. All the elements are locked together by a bolt  
19 through the neck. As the bolt is tightened, the head engages the  
20 neck and the bolt draws the link upwards resulting in the tapered  
21 tubular extension to be wedged between the external taper of the  
22 link and the internal taper of the trochanter bore.

23 In one embodiment, the weight-bearing component has a  
24 narrow distal end and a larger proximal end forming an external



1 shape approximating the natural bone. The weight-bearing  
2 component has a through bore from the distal end to the proximal  
3 end, with the proximal end of the through bore having a smooth  
4 circumference. The proximal end of the link is formed with  
5 opposite planar sides connected by curved walls. The distal end  
6 of the through bore has a circumference with opposite planar  
7 sides joined by curved surfaces. The circumference of the  
8 trochanter bore and the circumference of the proximal end of the  
9 link telescope together with the opposite planar surfaces in  
10 intimate contact with each other forming a rotationally secure  
11 connection with the artificial trochanter approximating the  
12 position of the natural trochanter.

13 The ball element has a planar distal end with a through  
14 bore. There is a cylindrical extension about the through bore  
15 adapted to be inserted into the proximal end of the through bore  
16 of the artificial trochanter. The extension and the wall of the  
17 trochanter bore may have complimentary shapes to interlock  
18 without rotational movement. Alternatively, there may be a key  
19 lock formed as a pin fitting into an aperture on the opposing  
20 contacting surfaces of the ball element and the trochanter. The  
21 proximal end of the through bore in the neck has an enlarged  
22 countersunk bore and the distal end of the through bore  
23 telescopes over the tapered tubular extension of the  
24 intramedullary rod. A screw threaded bolt is disposed in the

1 countersunk bore and threadably engaged with the screw threads in  
2 the proximal end of the link forming a locked integral  
3 prosthesis.

4       Accordingly, it is an objective of the instant invention to  
5 provide a joint with an intramedullary rod sub-assembly which is  
6 connected with the weight-bearing element in such a manner as to  
7 provide infinite rotational adjustment therebetween. Rotational  
8 movement, in this context, refers to the turning of either  
9 element in a plane normal to the common longitudinal axis of both  
10 elements.

11       It is an objective of the instant invention to provide a  
12 sub-assembly of an intramedullary rod and a link movably  
13 connected together by a tapered tubular extension permanently  
14 fixed to the intramedullary rod.

15       It is another objective of the instant invention to provide  
16 a locking mechanism between the intramedullary rod and the  
17 weight-bearing element to permanently fix the components together  
18 after rotational adjustment.

19       It is a further objective of the instant invention to  
20 provide the trochanter and the neck with a locking mechanism to  
21 rigidly secure the components together to prevent relative  
22 rotation.

23       It is a still further objective of the invention provide a  
24 locking mechanism between the neck element and the trochanter

1 element that permits rotational adjustment of the anteversion  
2 angle.

3 Other objectives and advantages of this invention will  
4 become apparent from the following description taken in  
5 conjunction with the accompanying drawings wherein are set forth,  
6 by way of illustration and example, certain embodiments of this  
7 invention. The drawings constitute a part of this specification  
8 and include exemplary embodiments of the present invention and  
9 illustrate various objects and features thereof.

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12 BRIEF DESCRIPTION OF THE FIGURES

13 Figs. 1 is a cross section of the prosthesis of this invention;

14 Fig. 2 shows a prospective view of the sub-assembly of the  
15 intramedullary rod and link;

16 Fig. 3 is a cross section of the intramedullary rod and the  
17 tubular extension; and

18 Fig. 4 shows a side view, partially in section, of the link used  
19 in this invention.

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21 DETAILED DESCRIPTION OF THE INVENTION

22 It is to be understood that while a certain form of the  
23 invention is illustrated, it is not to be limited to the specific  
24 form or arrangement of parts herein described and shown. It will

1 be apparent to those skilled in the art that various changes may  
2 be made without departing from the scope of the invention and the  
3 invention is not to be considered limited to what is shown and  
4 described in the specification and drawings.

5 The prosthesis 10, shown in Fig. 1, has an intramedullary  
6 rod 11 which provides stability. The distal end is inserted into  
7 the patient's femur and forms the stabilizing connection for  
8 maintaining the prosthesis in alignment with the axis of the  
9 femur. The distal end of the rod may have flutes to increase the  
10 surface area of the junction between the rod and the  
11 intramedullary canal of the femur. The distal end of the rod may  
12 also have a slot(s) 14 along the longitudinal axis of the rod to  
13 better accommodate the internal anomalies occurring in the  
14 interior of the intramedullary canal. This structure allows the  
15 distal end of the rod to compress to a smaller diameter to more  
16 easily reach the desired depth of insertion. Further, to  
17 accommodate the anatomy, the intramedullary rod may have an  
18 arcuate shape.

19 The link 13 and the intramedullary rod 11 are a pre-assembly  
20 12 with a tapered tubular extension 15 forming a joint between  
21 the link 13 and the rod 11. These pre-assembled components of  
22 the prosthesis may be made in different sizes and provided as  
23 part of a kit to accommodate different sized patients.

24 The link 13 is formed in a columnar shape with a threaded

1 bore 19 in one end and a bell shaped enlargement 29 near the  
2 other end. The end portion 51 of the link below the enlargement  
3 29 is inserted in a blind bore 21 in the proximal end 27 of the  
4 intramedullary rod 11. The relative sizes of the blind bore and  
5 the end portion are such that the rod and link can move  
6 rotationally and longitudinally. The mouth of the tapered tubular  
7 extension 15 is placed over the end of the link 13 that has the  
8 threaded bore 19 with the larger diameter of the taper towards  
9 the enlargement. The tubular extension is slid down the link to  
10 contact the proximal end 27 of the intramedullary rod 11. The  
11 base 43 of the tapered tubular extension and the proximal end 27  
12 of the intramedullary rod are permanently affixed about their  
13 respective circumferences. Depending on the materials used in  
14 the intramedullary rod and the tapered tubular extension, the  
15 seam 42 may be formed by a weld, such as by laser, causing  
16 autologous bonding or with additional flux or solvents, or  
17 adhesives. The connection of the rod and the extension leaves  
18 the link 13 a freely movable component.

19 The trochanter element 16 is mounted on the tapered tubular  
20 extension 15. The trochanter has a through bore portion 17. In  
21 which the extension 15 is inserted. As shown in Fig. 2, the  
22 proximal end 30 of the link 13 has corresponding mating surfaces  
23 which lock the elements together preventing any rotational

1 movement. The bore portion 17 has planar opposite sides and  
2 curved surfaces joining the ends of the planar sides. The  
3 proximal end of the link is sized to closely fit within the  
4 shaped bore portion 17. The proximal end of the link also has  
5 opposite planar sides 22 and 23 joined by curved surfaces 24 and  
6 25.

7 In Fig. 1, the link 13 and the intramedullary rod 11 are  
8 shown fixed by the tapered tubular extension 15. The tubular  
9 extension may be deformable or resilient and may be made from the  
10 same bio-compatible materials as the remainder of the prosthesis.  
11 Before the extension is fixed in position, the intramedullary rod  
12 and the link may, each, be rotated freely about their  
13 longitudinal axis. This allows infinite angular adjustment of  
14 the link which, in turn, orients the angle of the trochanter  
15 without stress on the connection between the distal end of the  
16 rod and the intramedullary canal. Then the inner wall 31 of the  
17 tapered tubular extension 15 is pressed onto the outer surface of  
18 the bell shaped enlargement 29. The outer wall 32 is pressed  
19 against the inner surface of a bore 17.

20 As mentioned earlier, these components may be provided in  
21 different lengths and diameters. The proper insertion of the  
22 link allows the immovable connection of the trochanter to the  
23 intramedullary rod in the approximate original position of the  
24 excised head of the femur.

1           The distal end of the bore 17 in the trochanter has a taper  
2   34 complementary with the exterior taper 32 of the tapered  
3   tubular extension 15.

4           The cooperating tapers 32 and 34 establish a precise limit  
5   to the distance the trochanter may be telescoped over the link.  
6   This limit, in turn, establishes the overall length of the two  
7   elements.

8           The link 13 has a blind bore 19 with internal threads 52 in  
9   the upper portion for receiving the threaded end of bolt 50  
10   securing the neck 40 to the trochanter 16.

11          The bolt 50 cooperates with blind bore 18 in the distal end  
12   of the link to longitudinally translate the link as the threads  
13   51 of the bolt are rotated within threads 52 and the head 53 of  
14   the bolt engages the counterbore 55 in the neck. As the bolt is  
15   rotated by an implement (not shown), the exterior taper of the  
16   tapered tubular extension 15 is press fit between the taper 34 of  
17   the distal end of the trochanter bore 17 and the internal wall is  
18   press fit with the enlargement 29 on the link. While a bolt is  
19   shown and described, other mechanical devices may be used to pull  
20   or push the link, the intramedullary rod, and the trochanter into  
21   a immovable press fit.     Therefore, the more the bolt is  
22   tightened, the more compression is applied to the press fit.  
23   Ultimately, all three components are rigidly connected to each

1 other. As shown and described, the link is telescoped into the  
2 proximal end of the intramedullary rod, obviously the telescoped  
3 components could be reversed.

4 The proximal end of trochanter 16 has a counter bore portion  
5 35 which has a greater diameter than the diameter of the through  
6 bore portion 17 in the distal end. Counter bore portion 35  
7 receives the distal end 45 of the neck element 40. This counter  
8 bore portion 35 may be cylindrical or conical. If conical, the  
9 walls of the counter bore portion 35 taper from a large diameter  
10 proximal end toward the distal end.

11 The counter bore portion 35 establishes a rotationally  
12 adjustable connection with the neck 40. This telescoped  
13 connection permits the prosthesis to be adjusted, after the  
14 intramedullary rod has been inserted into the femur, to  
15 approximate the natural location of the original ball.

16 The trochanter 16 is shaped like the natural femur head and  
17 has an outer diameter that is larger than the intramedullary rod  
18 at the distal end. The distal end of the trochanter is also  
19 inserted into the intramedullary canal. This junction of the  
20 trochanter and the shaft of the femur is the primary load  
21 carrying connection between the prosthesis and the patient's  
22 body. The trochanter flares to a larger diameter proximal end  
23 which has a planar surface 36 containing the counter bore  
24 portion 35. The bore 35 may include a linear portion forming a



1     recess. The recess or bore extension may receive the tang of the  
2     key lock, such as shown and described in U. S. Patent Application  
3     No. 09/982,448, to establish the anteversion angle between the  
4     trochanter and the neck. The bore extension may be formed as an  
5     extension of the counter bore 35, however the recess may be  
6     separated from the bore.

7             The neck 40 has a partially cylindrical body with a  
8     laterally extending arm 46 extending from the proximal surface  
9     of the body. This arm 46 carries the ball joint (not shown) for  
10    an artificial hip and can be specifically set at different  
11    anteversion angles to the trochanter and thus the axis of the  
12    femur with the key lock.

13            The distal end 45 is telescoped into the counter bore  
14    portion 35 of the trochanter. The outer surface of the distal  
15    end may be cylindrical or conical. A conical surface of the  
16    distal end tapers from a smaller distal end toward the proximal  
17    surface. The base of the conical pin is complementary sized with  
18    the through bore portion 35 so that a friction fit is established  
19    when the elements are telescoped together. This maintains the  
20    rotational axis relationship between the elements.

21            The proximal end of the bore 19 is countersunk to receive  
22    the head of the bolt 50.

23            The prosthesis may be assembled without compromising the  
24    union between the intramedullary canal and the intramedullary

1 rod. After the distal end of the rod is seated in the canal, the  
2 proximal end of the link is placed in the trochanter. The  
3 proximal end of the link can then be freely rotated to orient the  
4 shaped surfaces of the link and trochanter resulting in angular  
5 fixation of the position upon longitudinal translation.

6 Once the neck and trochanter are properly placed, The bolt is  
7 turned to engage the end of the threaded blind bore in link.  
8 Upon continued turning the proximal end of the link is  
9 longitudinally translated in relation to the intramedullary rod.  
10 Since the rod is fixed in the intramedullary canal, this causes  
11 the tapered tubular extension to engage both the distal end of  
12 the trochanter and the bell shaped enlargement in ever increasing  
13 pressure. By turning the threads of the bolt 50 into the threads  
14 52 of the link these cooperating screw threads tighten and the  
15 elements of the prosthesis are drawn together forcing the tapered  
16 distal end of the neck into a friction fit with the tapered bore  
17 of the trochanter and the trochanter to a stop limit with the  
18 intramedullary rod sub-assembly. In the final disposition, the  
19 trochanter and the link are locked together over a major part of  
20 the length of each. And the neck is locked to the rotationally  
21 immovable trochanter at a specific anteversion angle.

22 The various elements or components of the prosthesis may be  
23 made in different external sizes so that a range of elements is  
24 available to meet the size needs of various patients. However,

1 the interconnecting portions of the different sized components  
2 are of the same size or, at least, made in a range of sizes so  
3 that the different external sized elements may be securely  
4 connected as described above.

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